Perspectives on Sustainable Transport

Lew Fulton
Director, Sustainable Transportation Energy Pathways (STEPS) Program

ARPA-E Vehicle Energy Storage Technologies Annual Program Review

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ITS UCDAVIS INSTITUTE OF TRANSPORTATION STUDIES

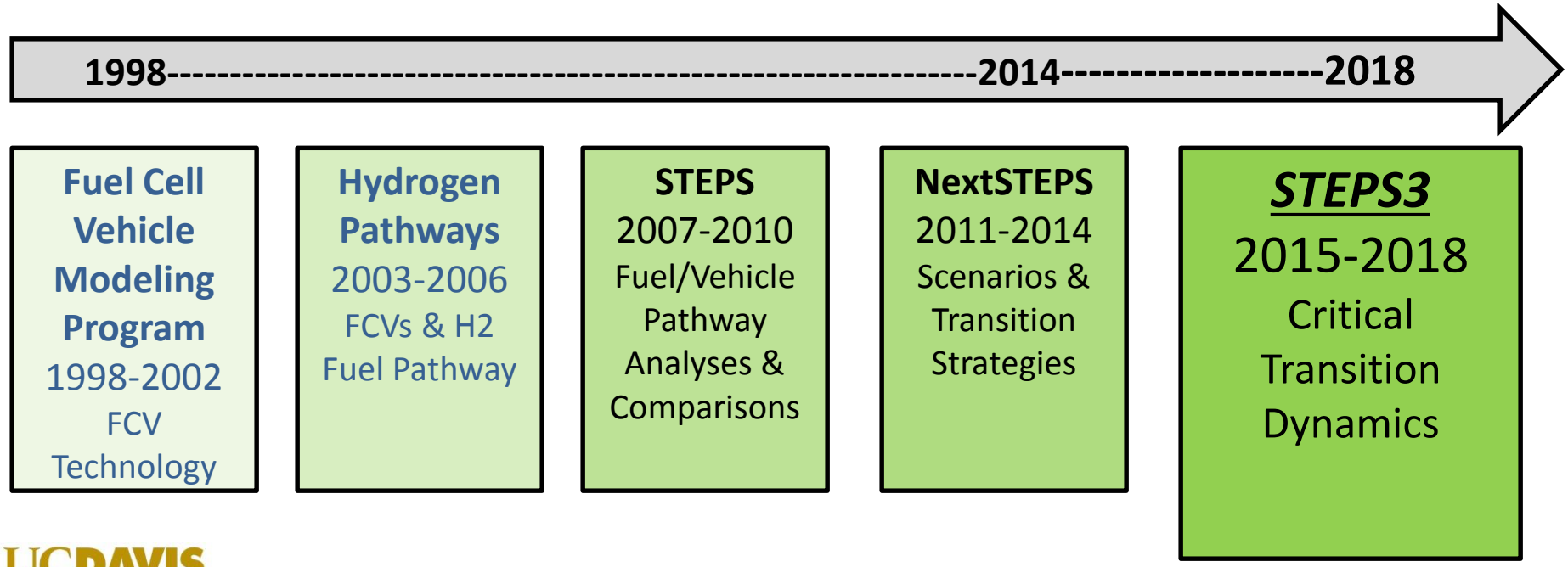
To cover today

- The climate imperative – COP-21
- Challenges – Oil
- Challenges – biofuels and NG
- Challenges – electric drive vehicles

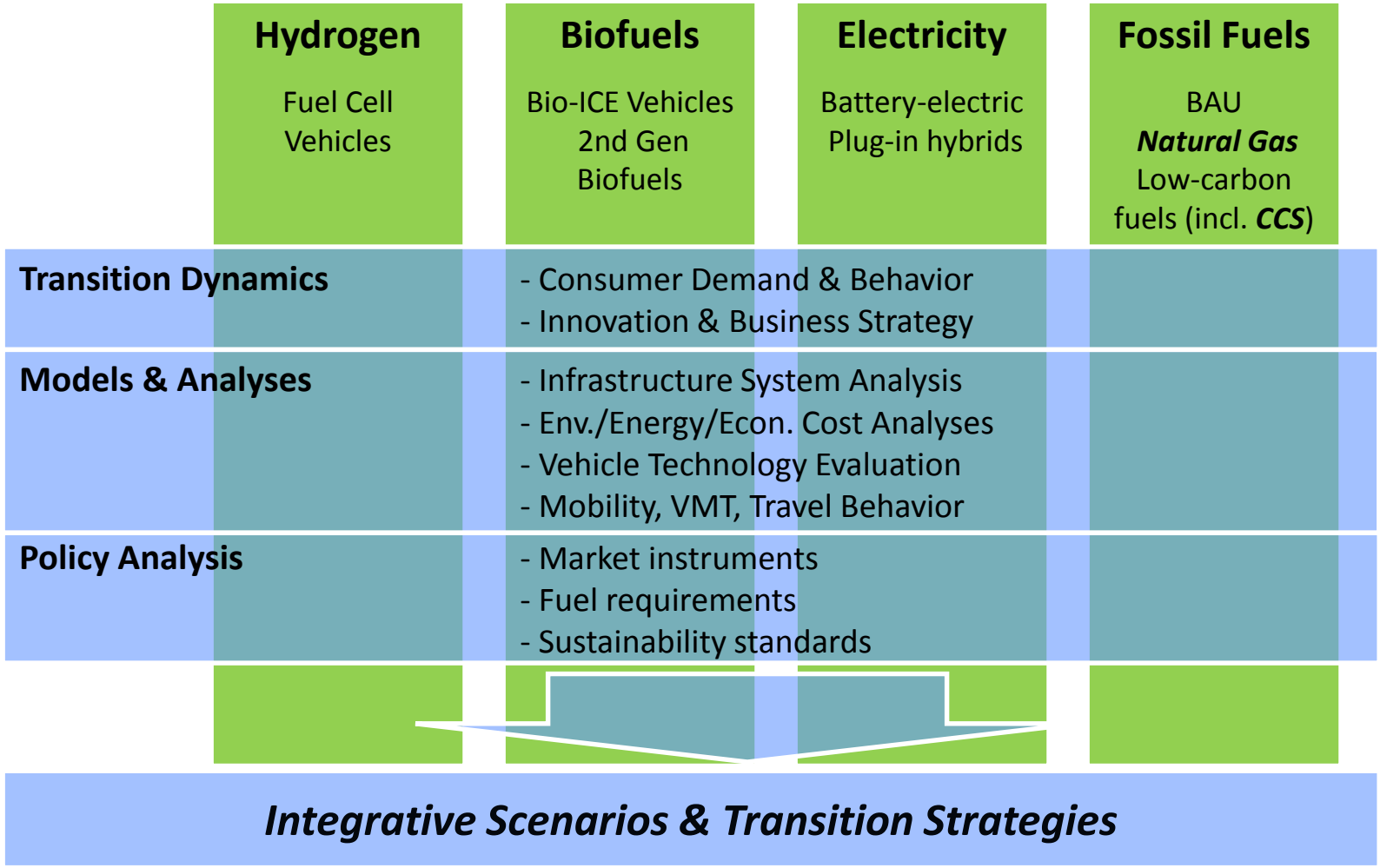
STEPS is the leading global forum of low-carbon transportation stakeholders

We generate visions of fuel and vehicle futures grounded in technical and economic realities, a strong knowledge base for companies making long-term technology investments, and sophisticated analyses of future policies.

- Modeling and analyzing alternative fuel transitions
- Preparing scientific analysis and convening policy and business decision makers
- Training next generation leaders in transportation and energy



Sustainable Transportation Energy Pathways (STEPS) Program at ITS-Davis



We use our STEPS research framework to analyze and compare alternative fuel and vehicle transitions

UCDAVIS
SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

STEPS has world's top leaders on alternative fuels, transportation, oil and gas, EVs, and scenarios modeling

Joan Ogden, Professor/STEPS Director: world's top expert on *economic assessment of fuels, esp. hydrogen*

Lew Fulton, STEPS Director: leading analyst on *global sustainable transport scenarios*, formerly at IEA

Dan Sperling, Professor/STEPS Co-Director/ITS-Davis Founding Director: leading global expert on *sustainable transportation and policy*

Amy Myers Jaffe, Exec. Dir., Energy & Sustainability: leading global expert on *oil and gas and sustainable energy*

Andy Burke, Research Engineer: leading expert on *vehicle technology evaluations*, esp. batteries and supercapacitors

Sonia Yeh, Research Engineer: leading *energy modeling* known for innovative strategies on big data, GIS mapping and *national policy*

Tom Turrentine, Dir., PH&EV Research Center: consumer response to alternative vehicles, esp. *PEV market*

STEPS 2015-2018 Consortium Members



Observations on the Climate Conference (COP-21) in Paris, Dec 2015

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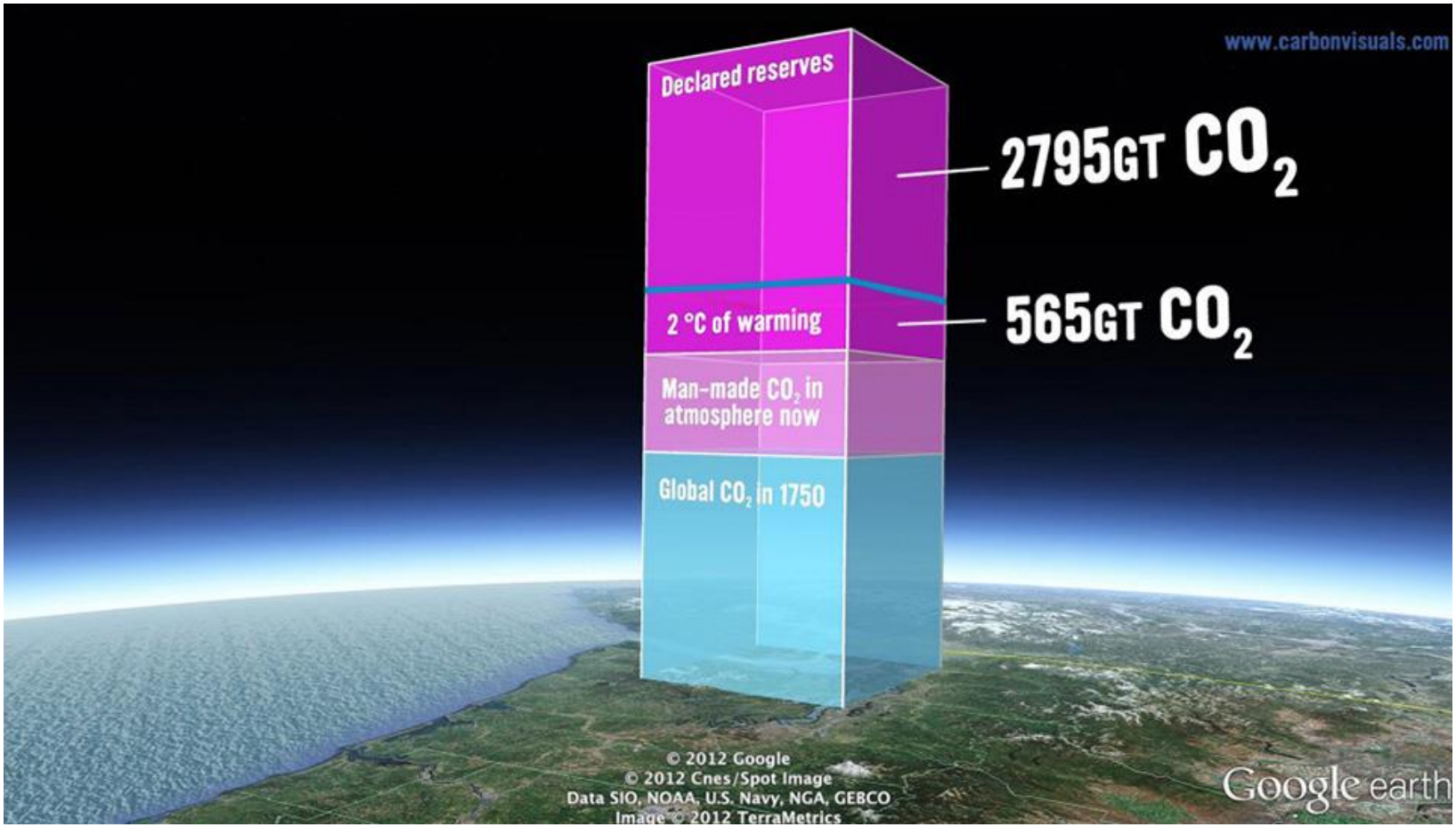
www.steps.ucdavis.edu

Two degrees: mostly unburnable carbon



Outcomes from Paris COP-21

- 195 Nations signed an agreement on a new post-2020 framework with targets and mechanisms
- The 2 degree goal was retained, with much text around the need for a 1.5 degree target.
- Financing mechanisms were strengthened
- Nationally determined commitments were announced
- Adaptation/resiliency plans were strengthened

Worst acronym award:

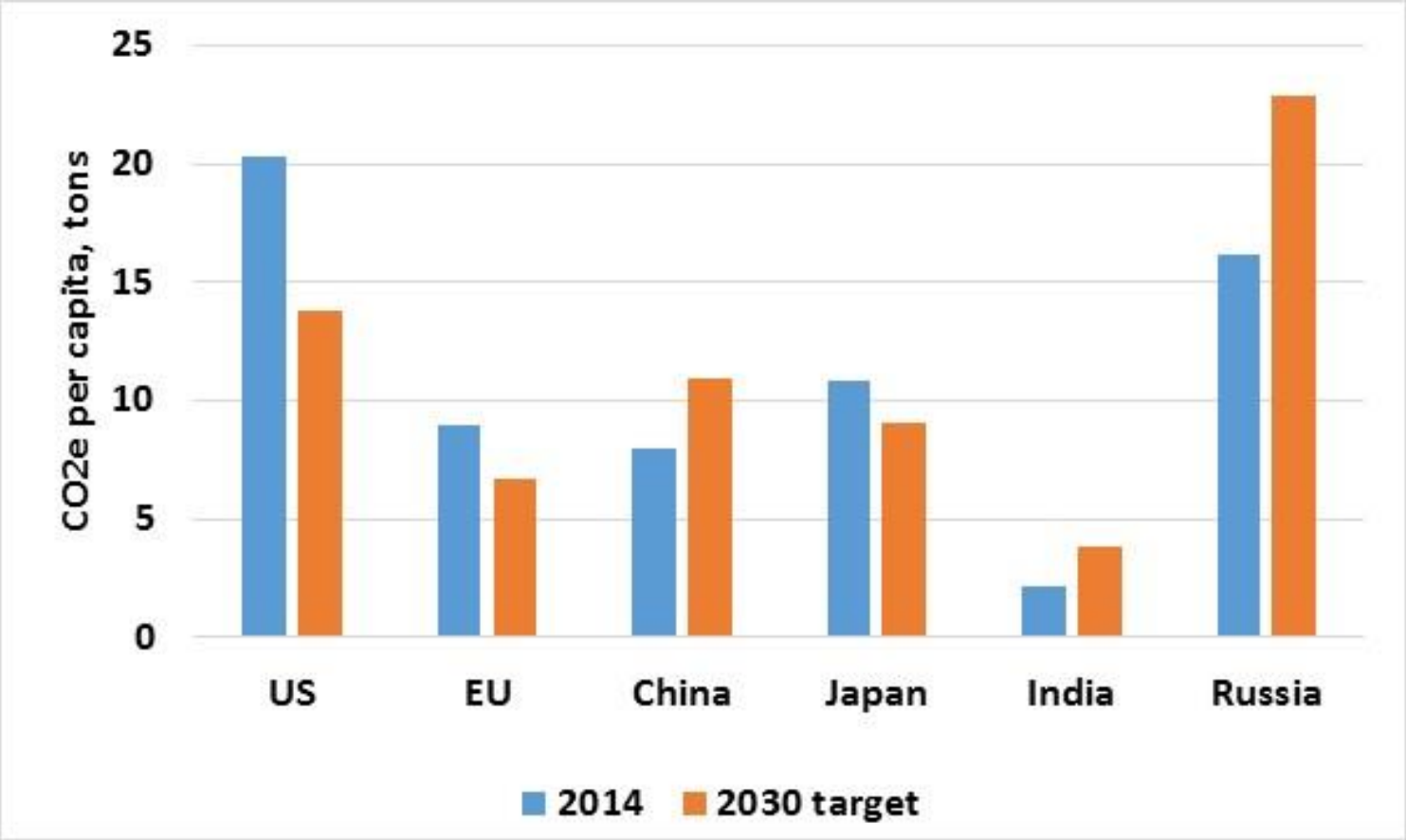
CBDRRCILNDC- "Common But Differentiated Responsibilities and Respective Capabilities In the Light of Different National Circumstances"

- Slightly better is "INDC" – Intended Nationally Determined Contributions

The U.S. INDC

- 26-28% reduction in CO2 emissions by 2025, compared to 2005
- Commitments across sectors not specified, but key elements include:
  - Clean Power plan – 30% reduction in CO2 by 2030
  - Buildings, appliance standards
  - Transportation also expected to play a major role:
    - Fuel economy/CO2 standards for cars and trucks
    - Alternative fuel initiatives
    - Travel-related policies?

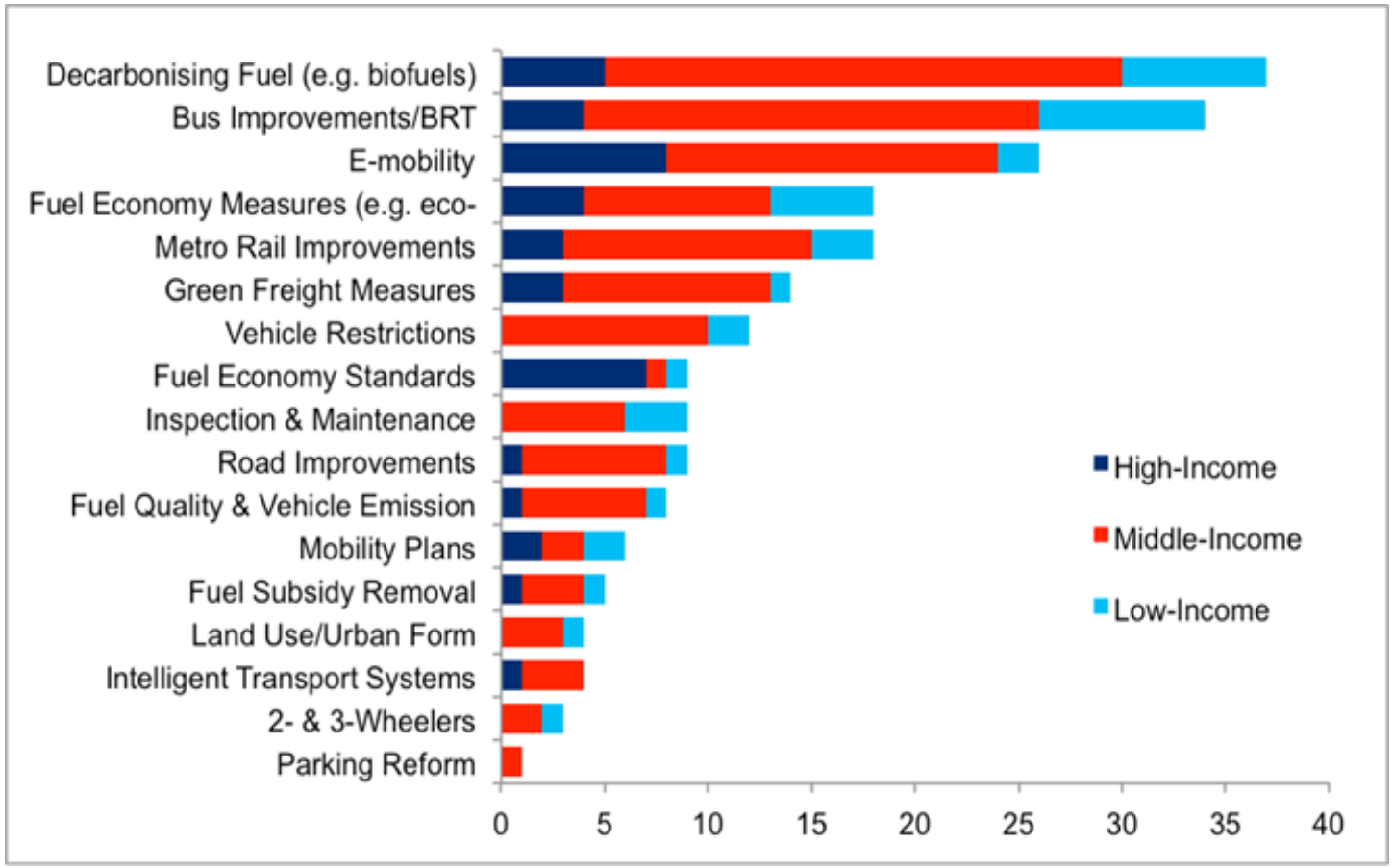
INDC Commitments for Selected Countries



All energy-related CO_2 emissions per capita *for selected countries, for 2014 and explicit or implied targets for 2030 (based on analysis conducted by climateactiontracker.org, using national INDC reports; for 2030 approximate midpoints are used where a range of targets or uncertainty in targets may exist; these are meant to be indicative and are not official numbers). Full blog describing this is located at:* ***http://its.ucdavis.edu/blog-post/paris-climate-accord-a-strong-call-to-action-including-transportation/***

Target data is based on: http://climateactiontracker.org/countries/china.html

Transportation Measures Mentioned in INDC plans



Typology of Transport Mitigation Strategies in Intended Nationally-Determined Contributions (SLOCAT, 2015)

http://its.ucdavis.edu/blog-post/an-american-transportation-researcher-in-paris-report-from-cop21-the-global-climate-conference/

Paris Declaration on Electro-Mobility and Climate Change & Call to Action

Released in Paris during COP21, signed by 20+ organizations including UN, auto manufacturers and NGOs (and groups representing them).

http://newsroom.unfccc.int/lpaa/transport/the-paris-declaration-on-electro-mobility-and-climate-change-and-call-to-action/

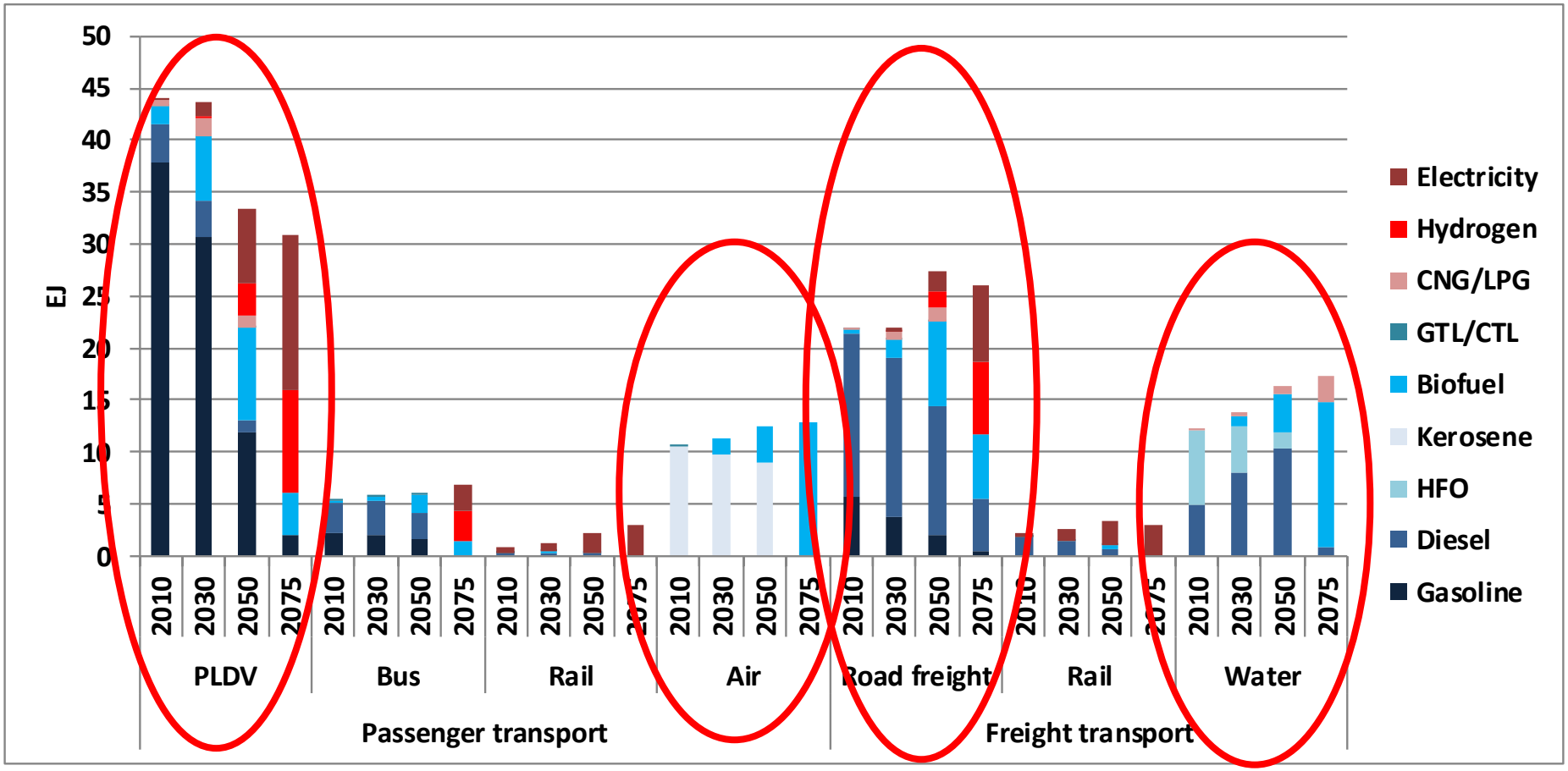
Key clauses:

With varying mandates, capabilities, and circumstances, ***we commit to advance our work individually as well as collectively wherever possible to increase electro-mobility to levels compatible with a less-than 2-degree pathway….****We also call on governments at all levels, businesses, cooperative initiatives, and others to commit to this Declaration, take action, and advance global momentum for electro-mobility.*

According to the International Energy Agency, this transition will require… at least 20 percent of all road transport vehicles globally to be electrically driven by 2030 If warming is to be limited to 2 Degrees or less. Of this, light vehicles would primarily contribute: more than 400 Million two and three-Wheelers in 2030, Up from roughly 230 Million today; ***and more than 100 Million cars in 2030, Up from 1 Million today.***

One global 2°C Transport Scenario

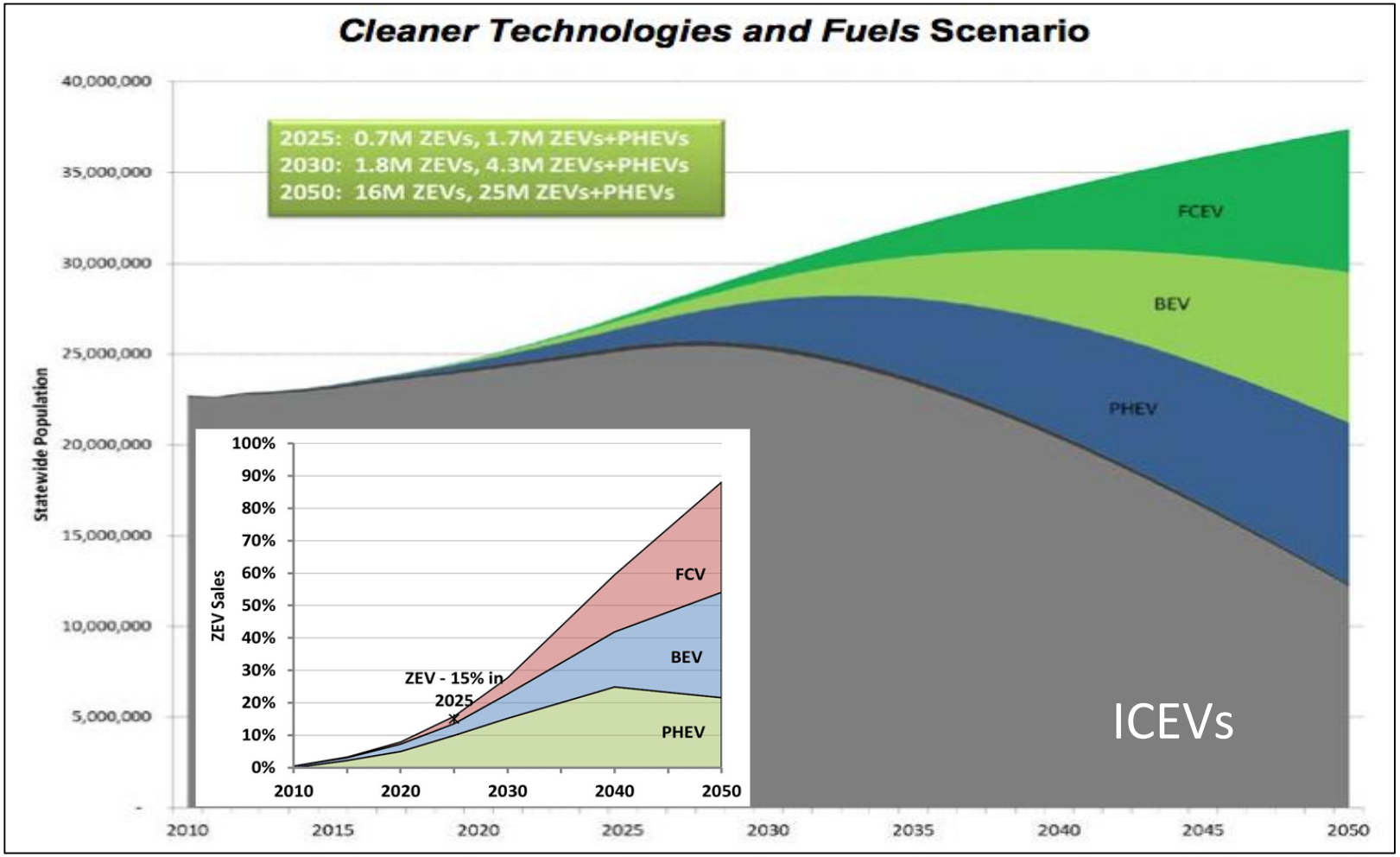
- Transport part of a global effort; electricity and hydrogen key for cars and trucks



Fulton et al, 2015, in *Biofuels, Biorefining and Bioproducts"*

CARB Scenario to Achieve 2030 & 2050 GHG Targets (-40% and -80%)

→ 90% ZEV/PHEV sales by 2050 (2/3 of on-road vehicles)



Disruptive Factors and Obstacles

“Three major linchpins to high oil price psychological exuberance have dissipated“

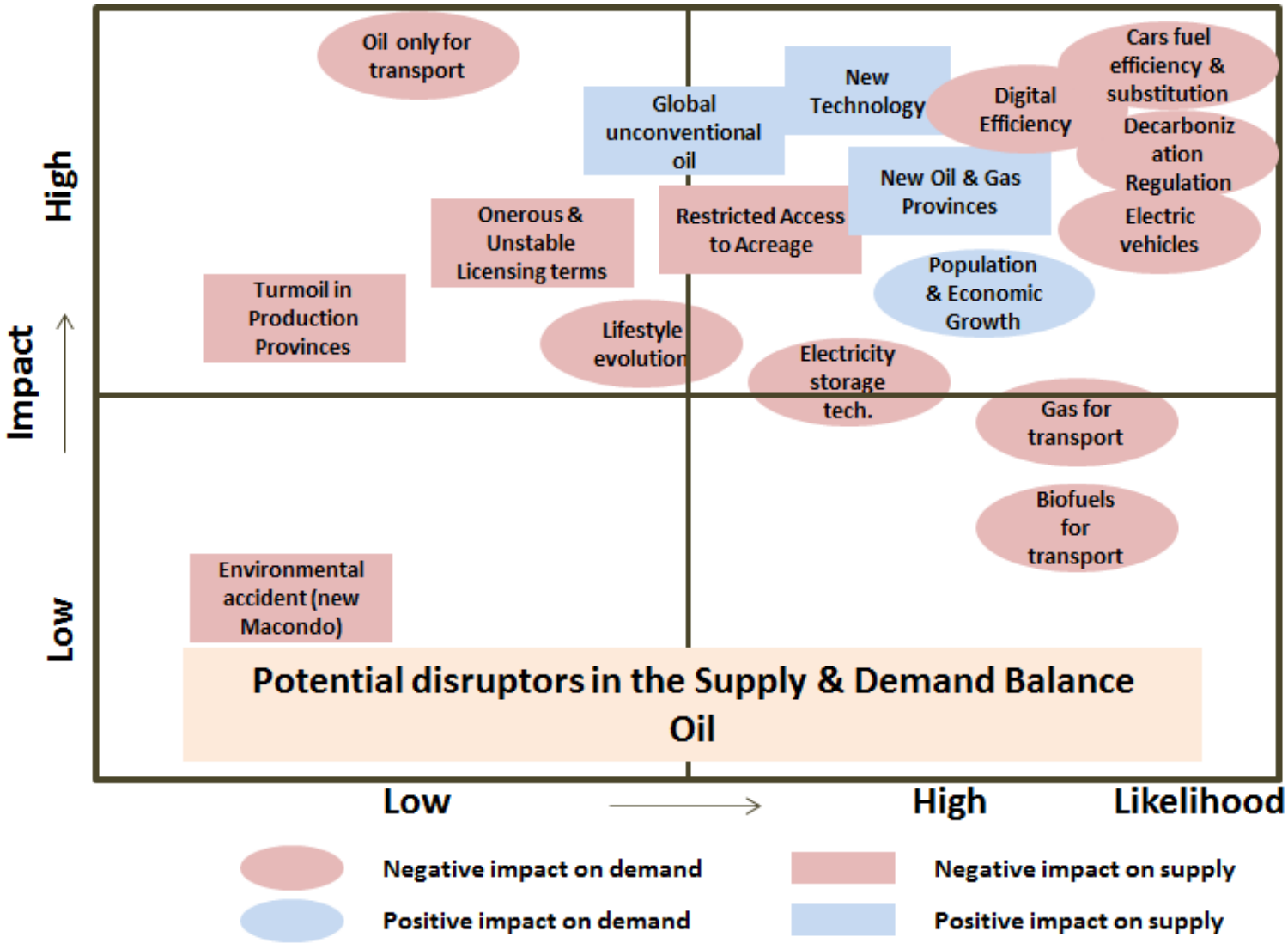
- Amy Jaffe, UC Davis

2002–2015 up-end of the price cycle was mainly driven by three characteristics that no longer prevail:

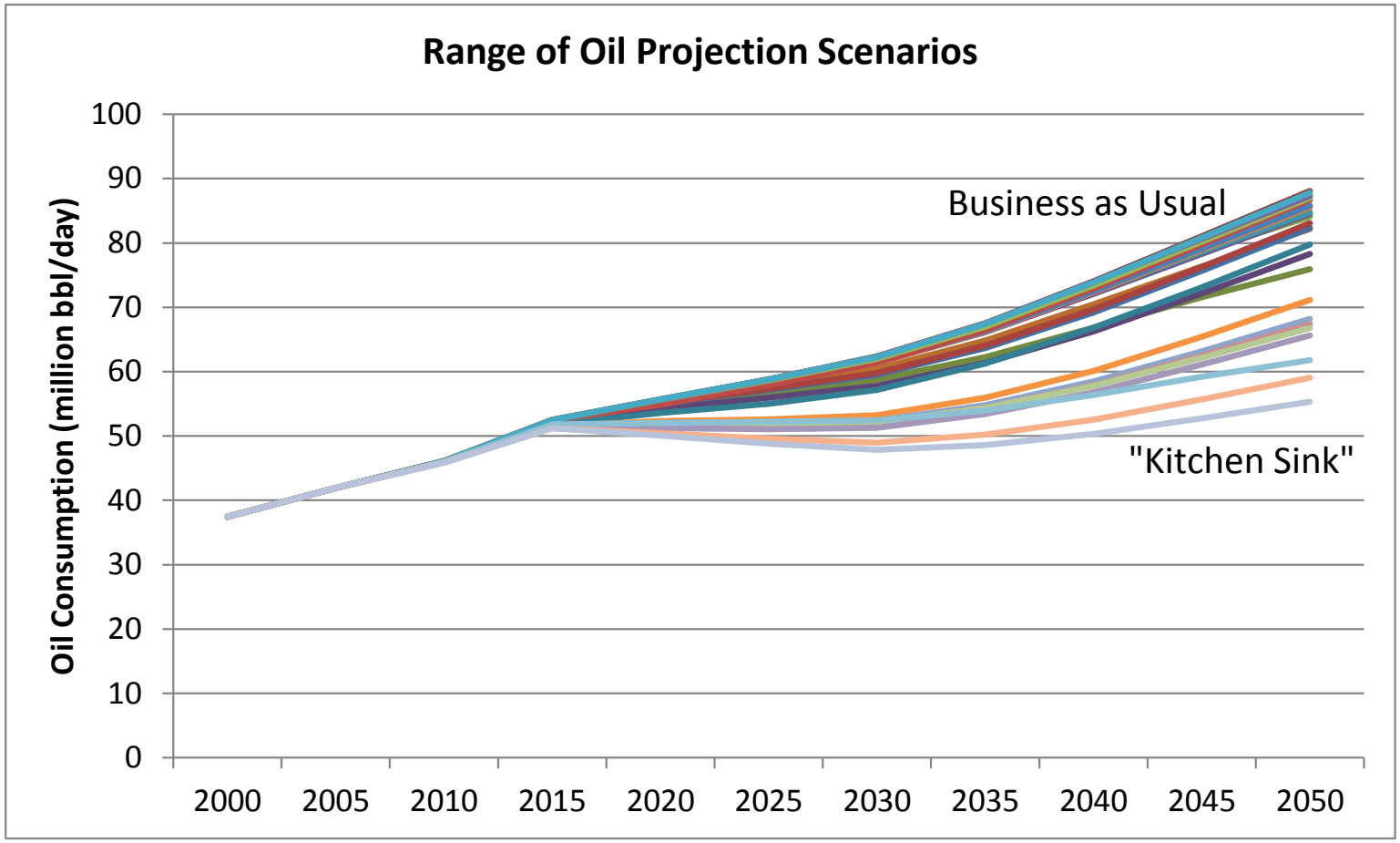
- “Peak Oil” theory
- Steady, rapid Chinese “demand” based on industrial growth
- Rising upstream services costs

Potential disruptors in the supply & demand balance of oil

Potential disruptors in the supply&demand balance of oil are mostly driven population growth and economic development, new technological developments on both production and consumption, and regulatory restrictions to carbon emissions.



We've looked at factors outside of policies that could result in flatter oil demand trends



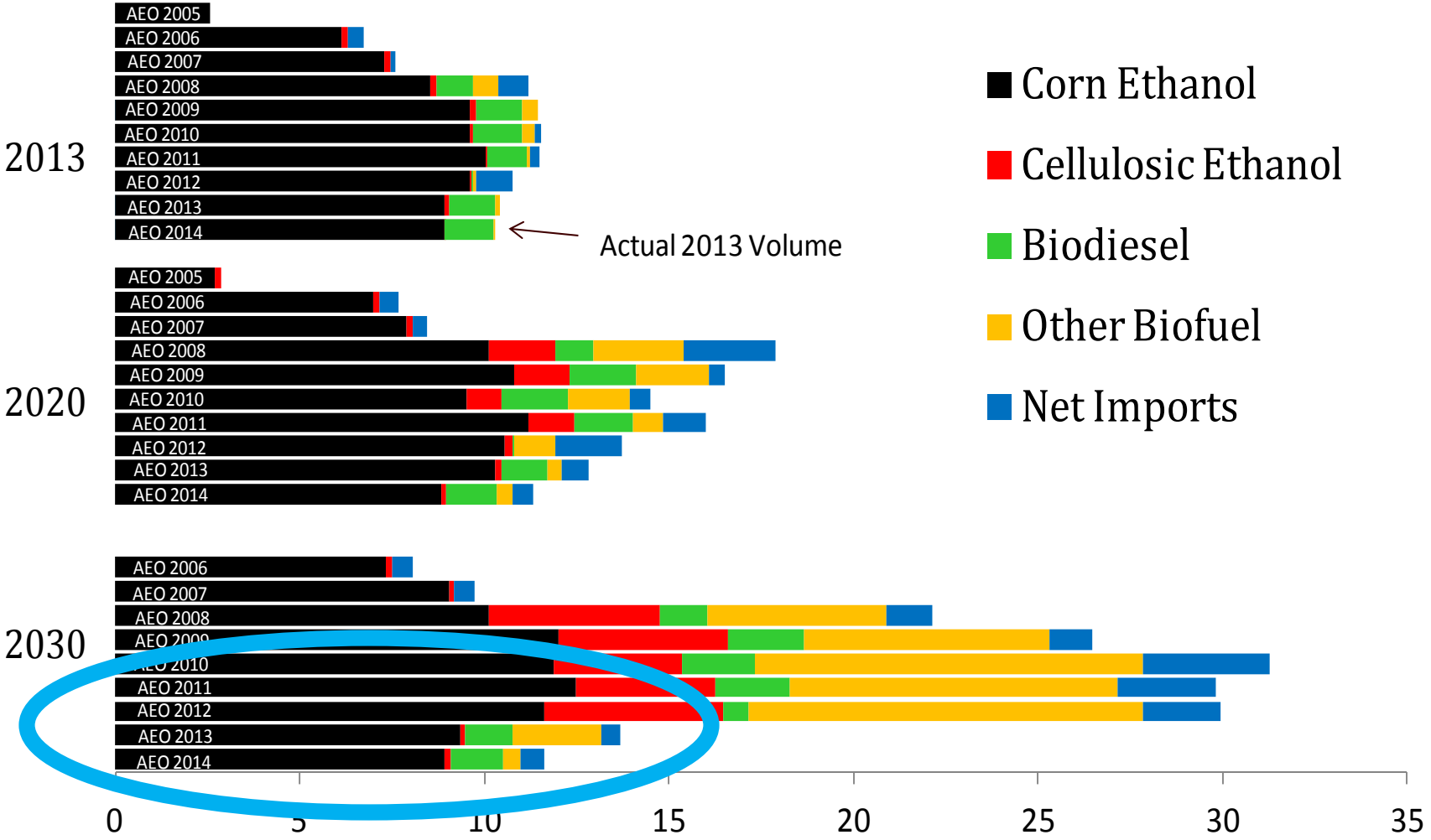
- Possible stagnation of oil demand through 2035 before growth resumes

What is available to achieve a two degree scenario?

- A very quick look at:
  - Biofuels
  - Natural gas
  - Fuel cells/hydrogen

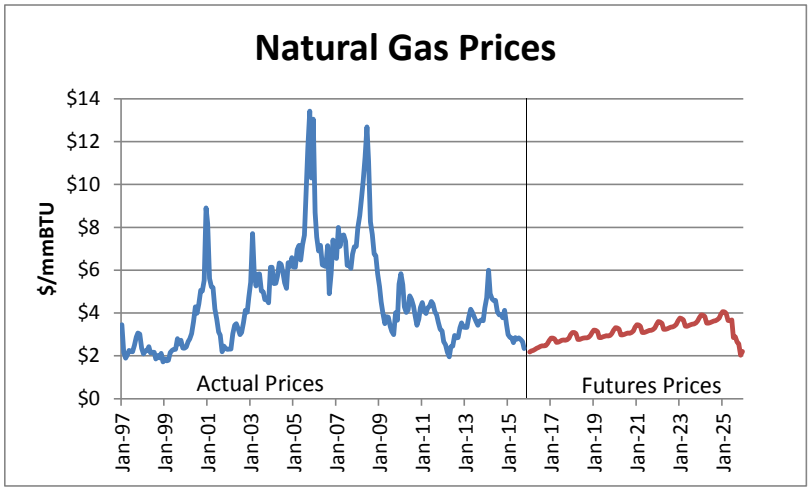
The Rise and Fall of Biofuels in the Minds of the EIA

Projections in successive AEO's, 2004-2014

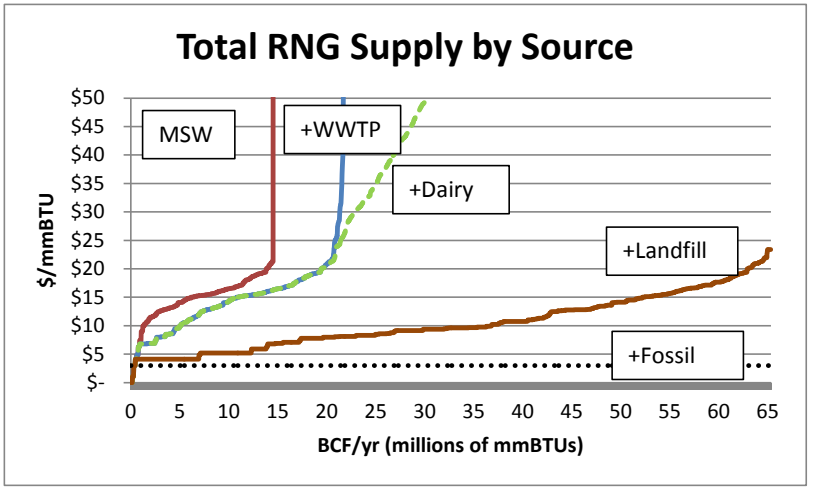


Natural gas and Renewable Natural Gas (RNG)

Fossil natural gas prices are low and projected to remain low into the future



RNG is expensive to produce

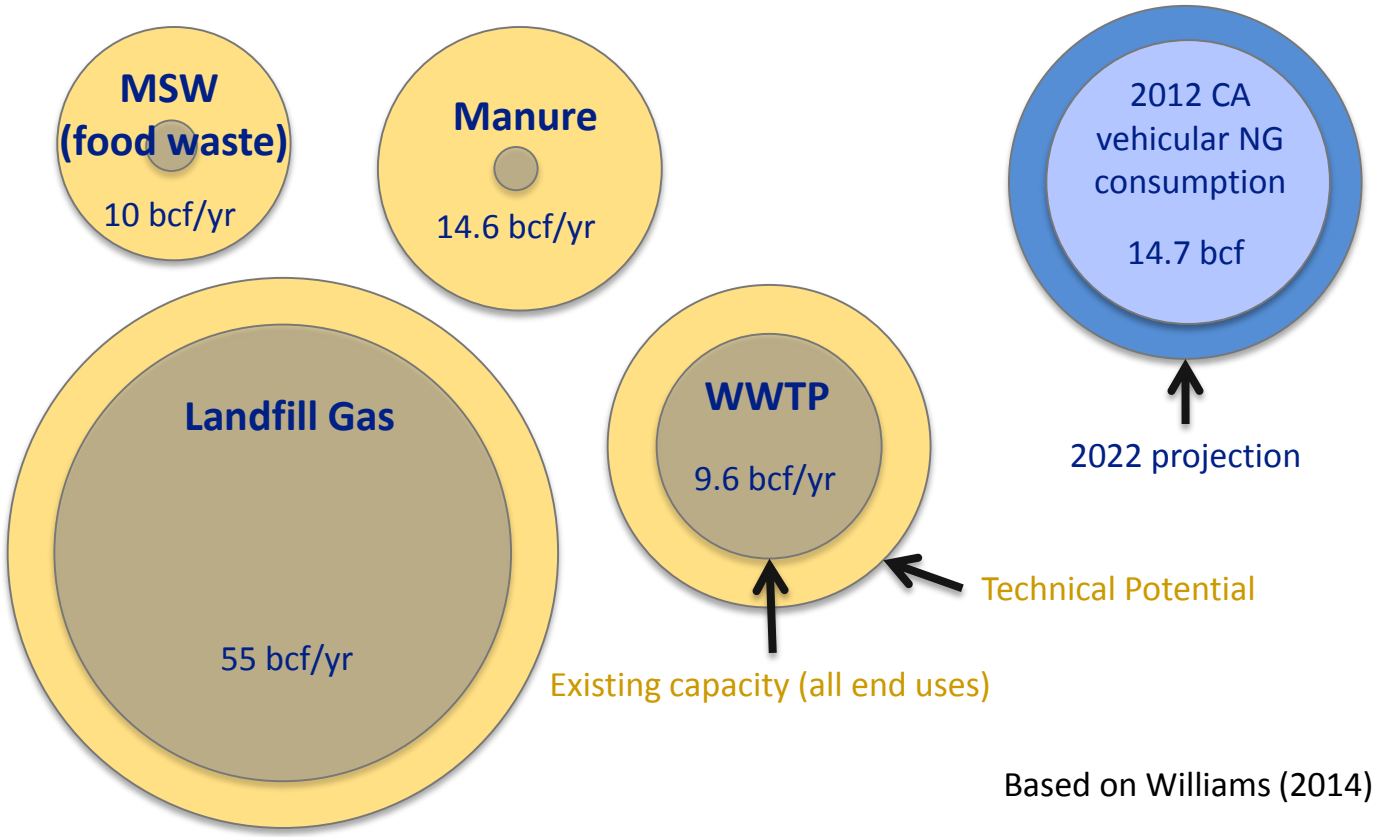


Further Barriers

Uncertainty: Credit prices are variable, Carbon Intensities subject to change, long-term contracts unavailable

Credit price ceiling may not be high enough to encourage RNG requires support unless carbon intensities change or compliance target falls beyond 2020 goal

And much of the limited RNG is already being used



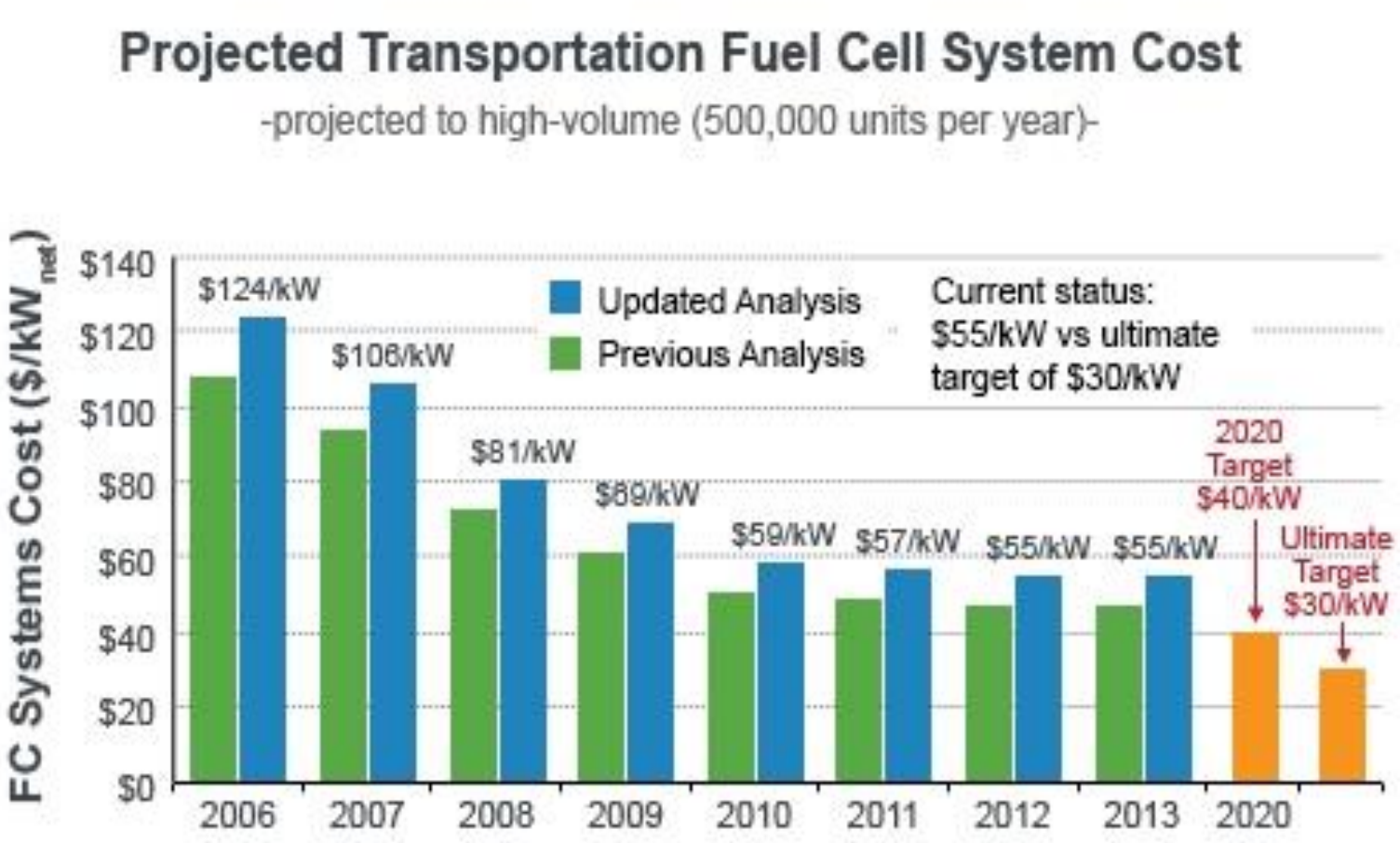
Based on Williams (2014)

Fuel Cell Vehicles are here, but it's early days

FCV Market Intro. Dates Announced by Automakers

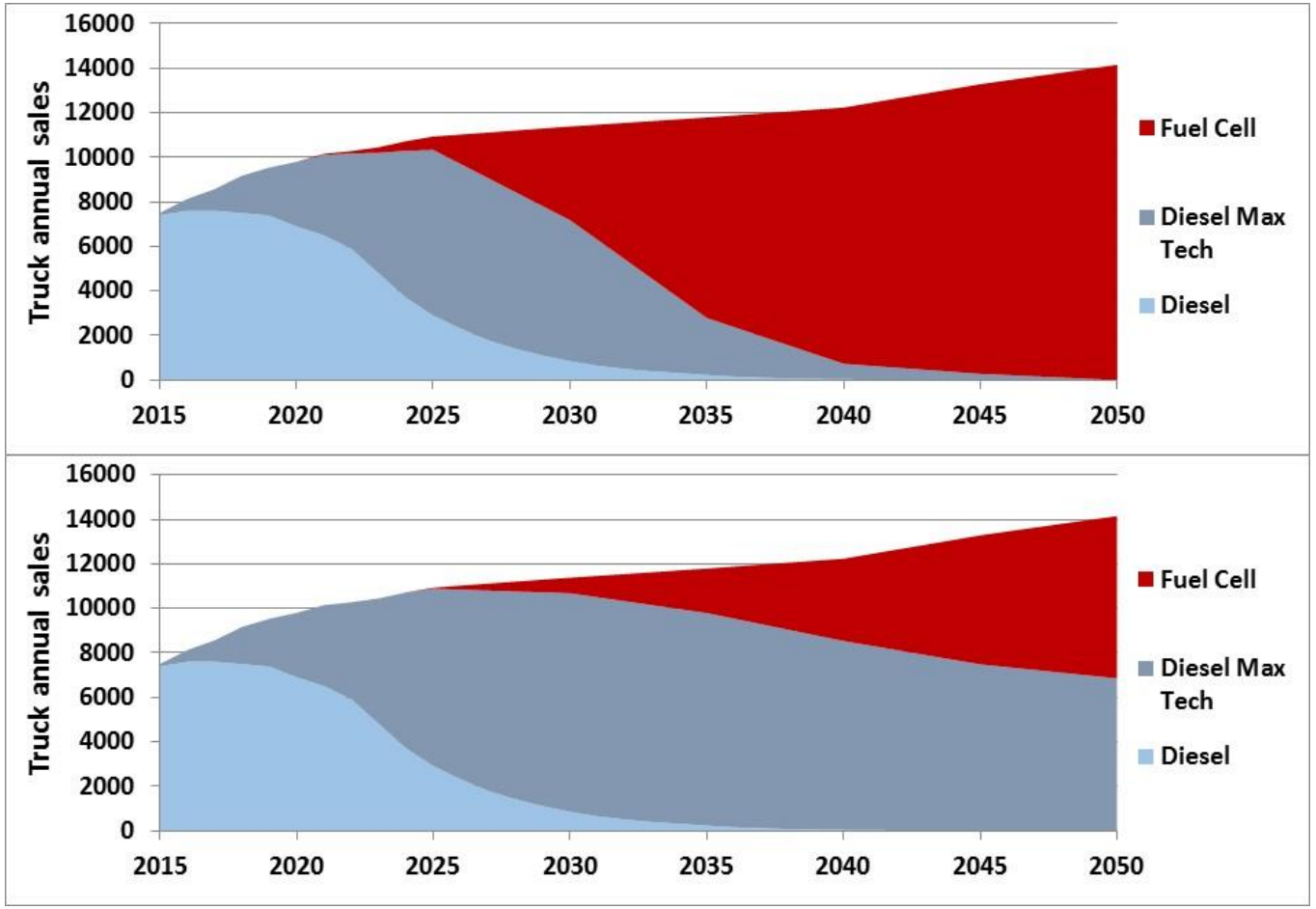
Company	Previous demos	Commercialisation dates			
		Before 2015	2015-2016	2017-2018	2019-2021
BMW	7 generations of H_2 ICE saloons				
Daimler	>100 B-Class vehicles				
Honda	>100 FCX clarity (C-Class FC car)				
Hyundai	Now deploying a fleet of ix35 SUV's				
Nissan	30 X-Trail SUV in US/Japan				
Toyota	~100 SUV vehicles US/Japan/Germany				

DOE: Progress in FC Technologies



Trucks will need to transition, and their path is very unclear

Two possible scenarios to cut long-haul CO2 by 80% in 2050



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(STEPS Freight White Paper, June 2015)

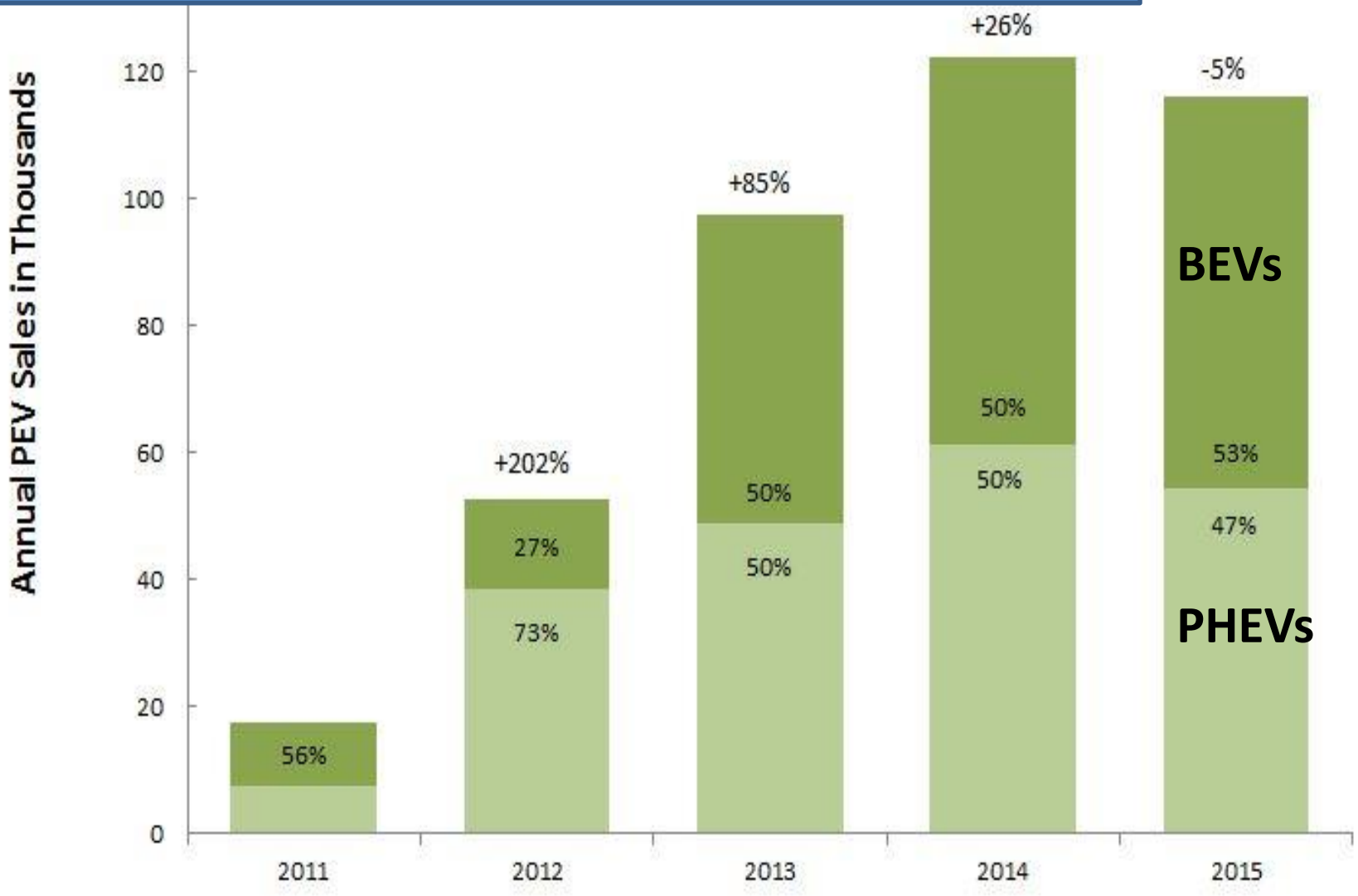
What is available to achieve a two degree scenario?

- And finally…
  - Electric vehicles

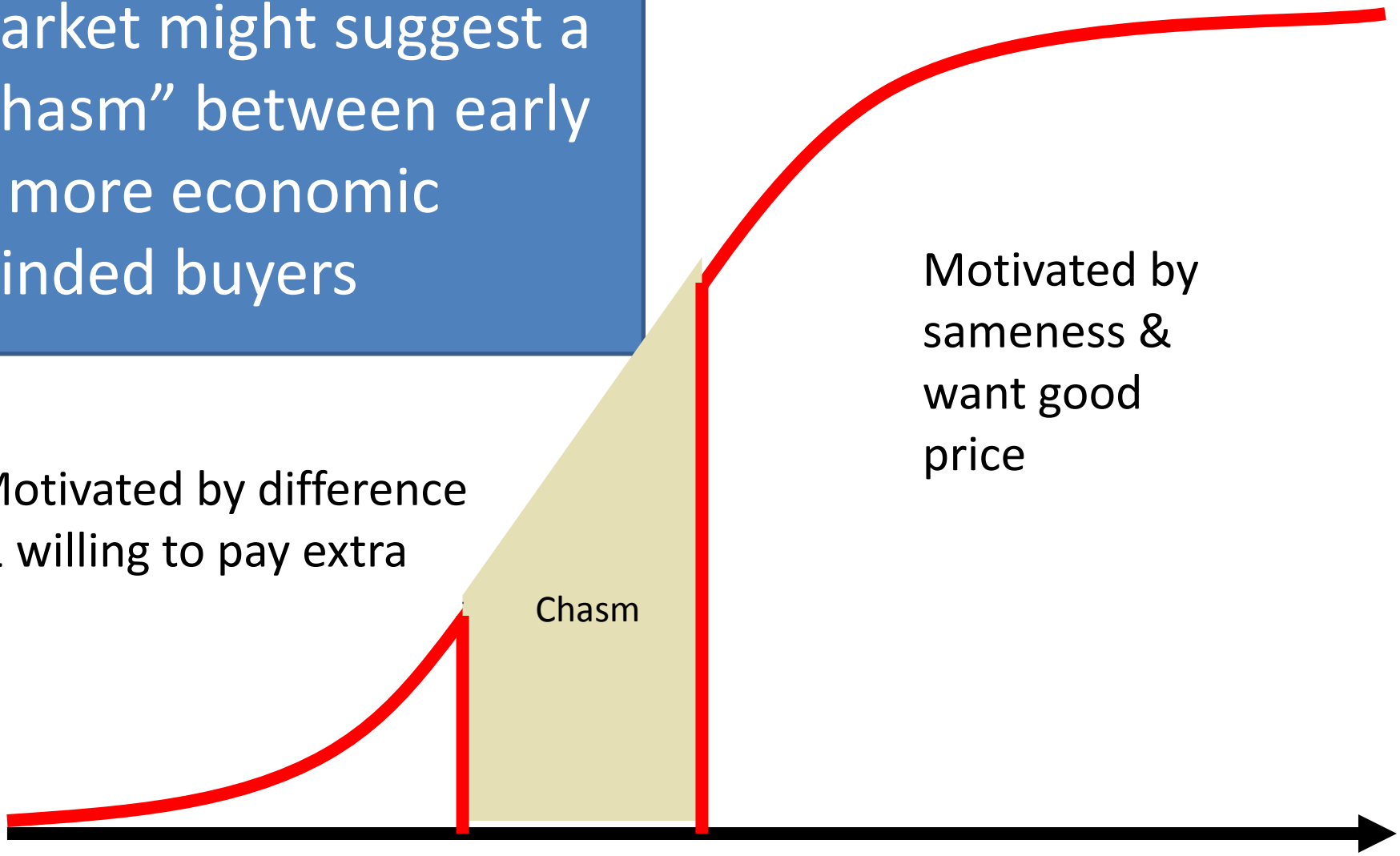
US Annual PEV Sales slowing in 2015

- Total LDV vehicles in USA > 250 million
- USA LDV sales 2015 = 17.5 million
- Total PEVs registered in USA > 450,000

Data from insideevs.con



The slowing of the market might suggest a "chasm" between early & more economic minded buyers



A plausible California scenario based on laws, incentives & history of previous technology rollouts

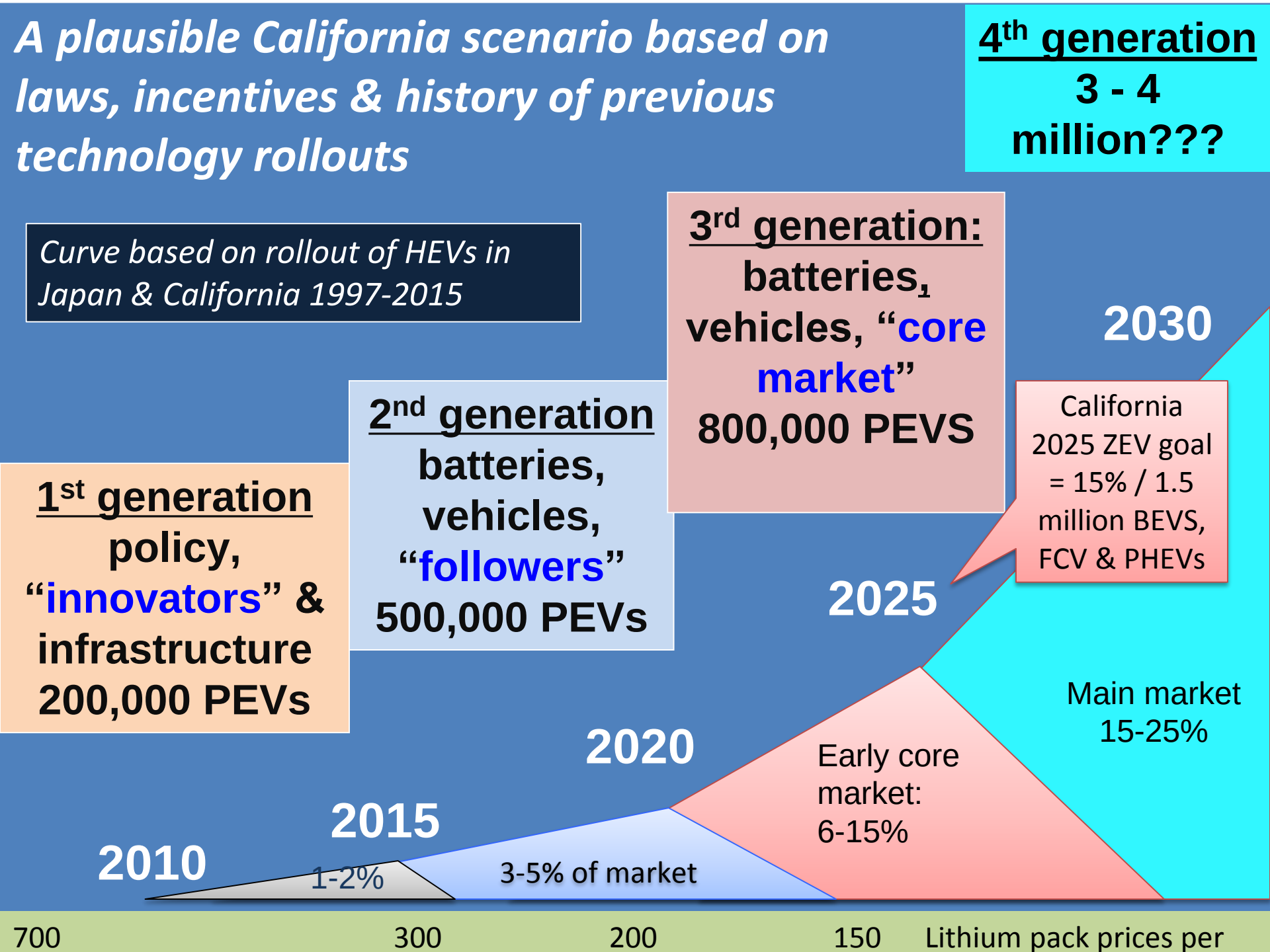
4th generation
3 - 4 million???

Curve based on rollout of HEVs in Japan & California 1997-2015

3rd generation: batteries, vehicles, "core market" 800,000 PEVS

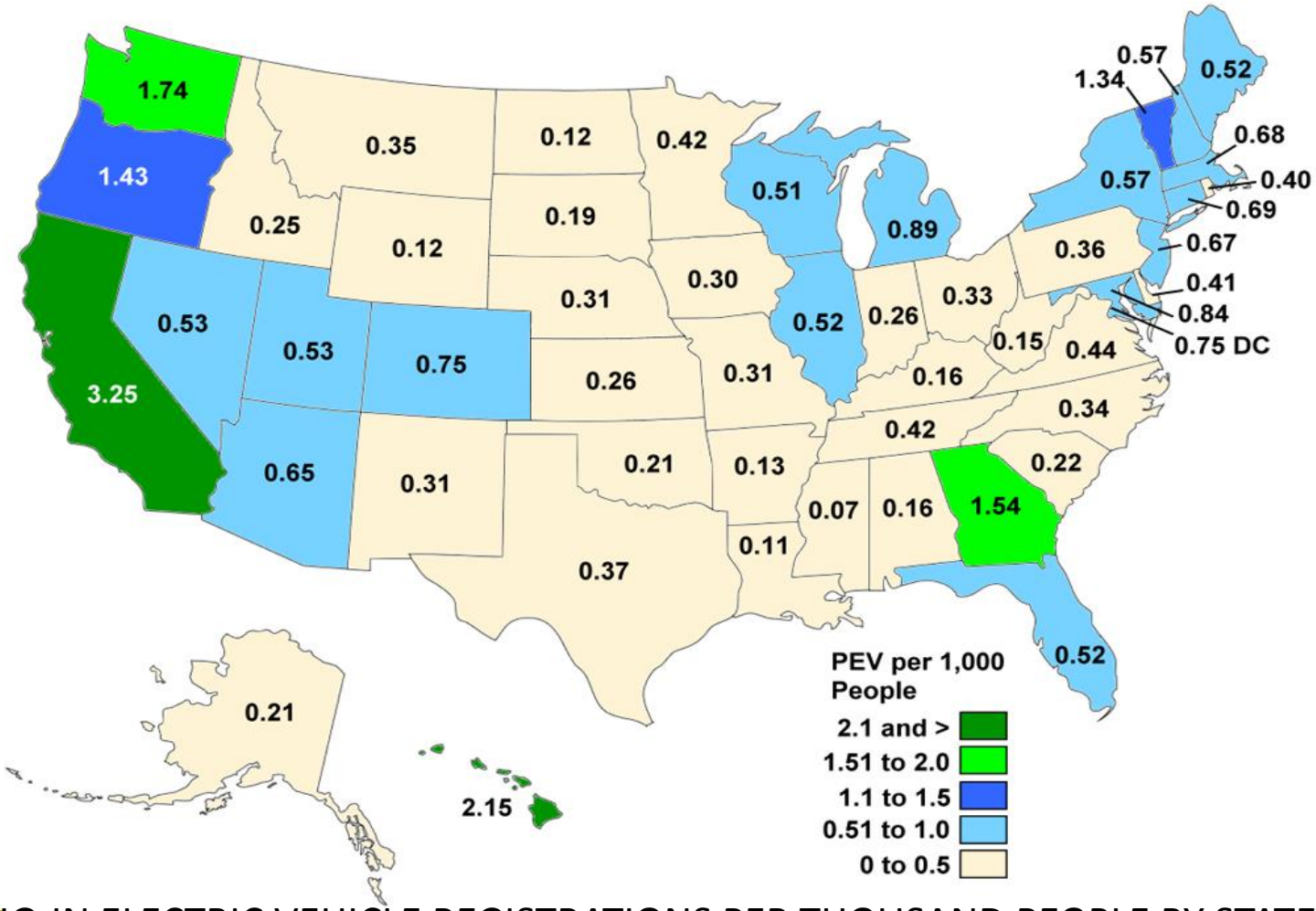
2nd generation batteries, vehicles, "followers" 500,000 PEVs

1st generation policy, "innovators" & infrastructure 200,000 PEVs



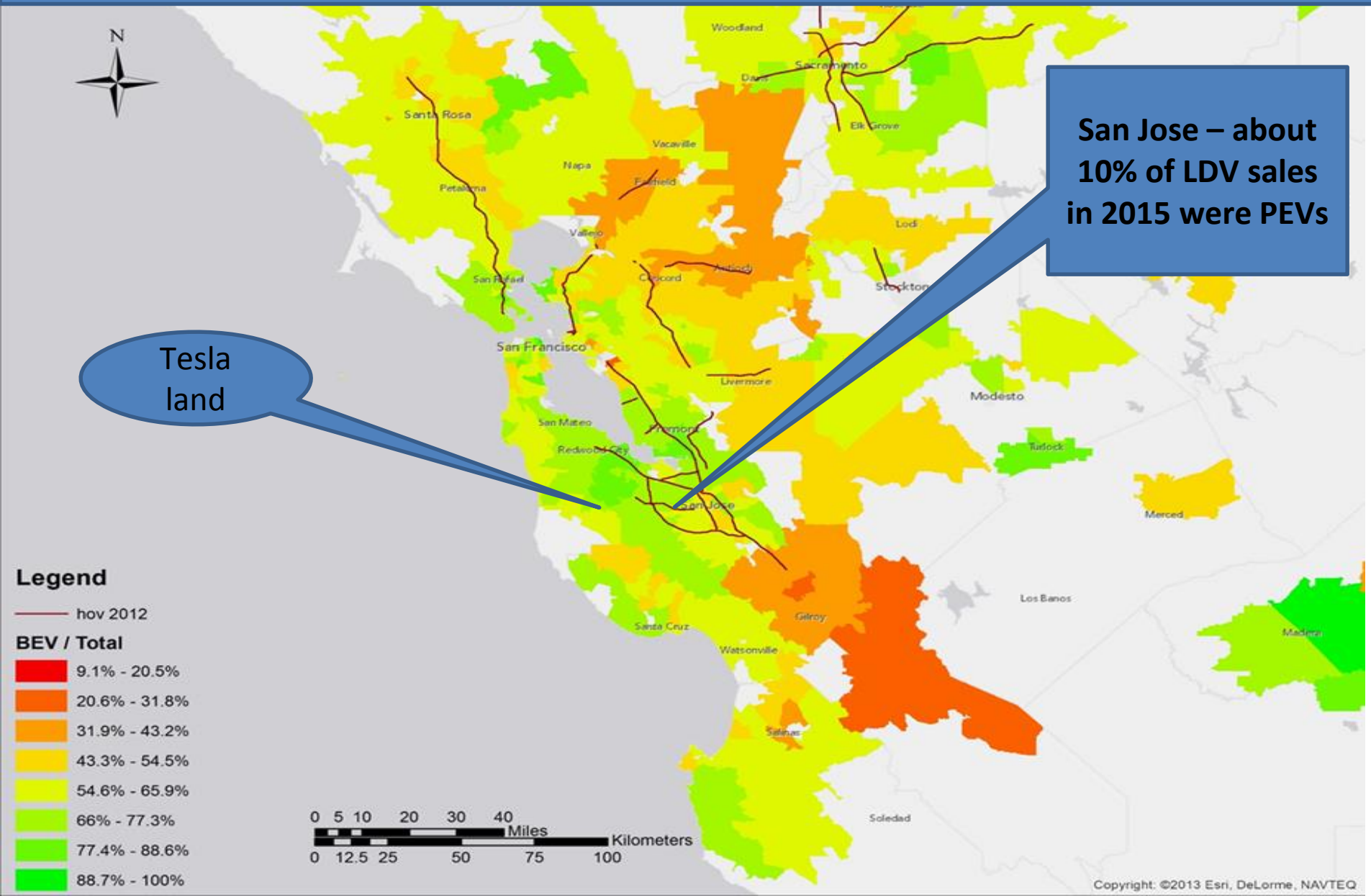
Why is California doing well?

1. ZEV laws & success with regulation of clean air 2. High income car culture 3. "Tech" industry

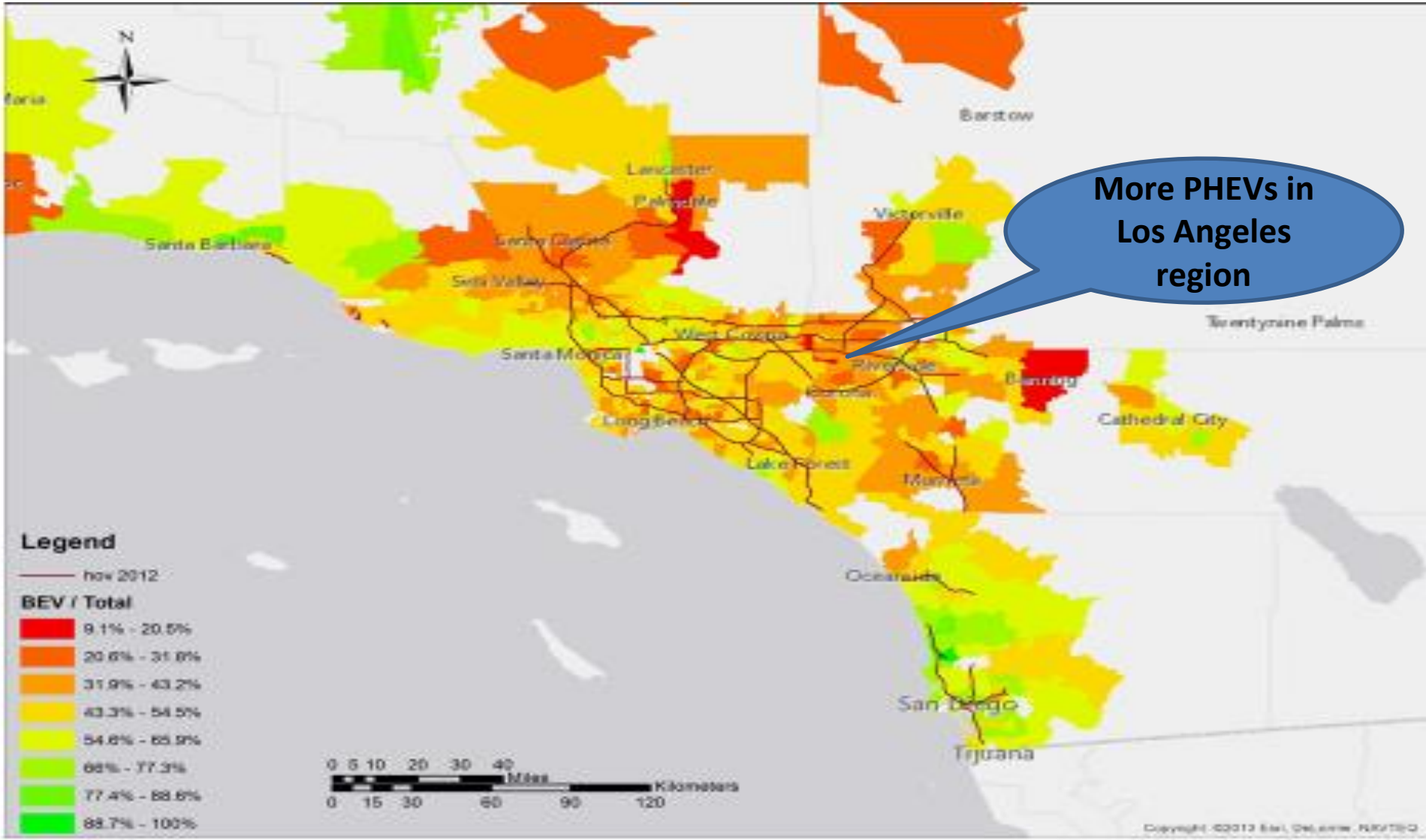


PLUG-IN ELECTRIC VEHICLE REGISTRATIONS PER THOUSAND PEOPLE BY STATE, 2014
National Renewable Energy Laboratory analysis, R.L. Polk,

The technology industry in the San Francisco Bay Area creates strong markets for new technology



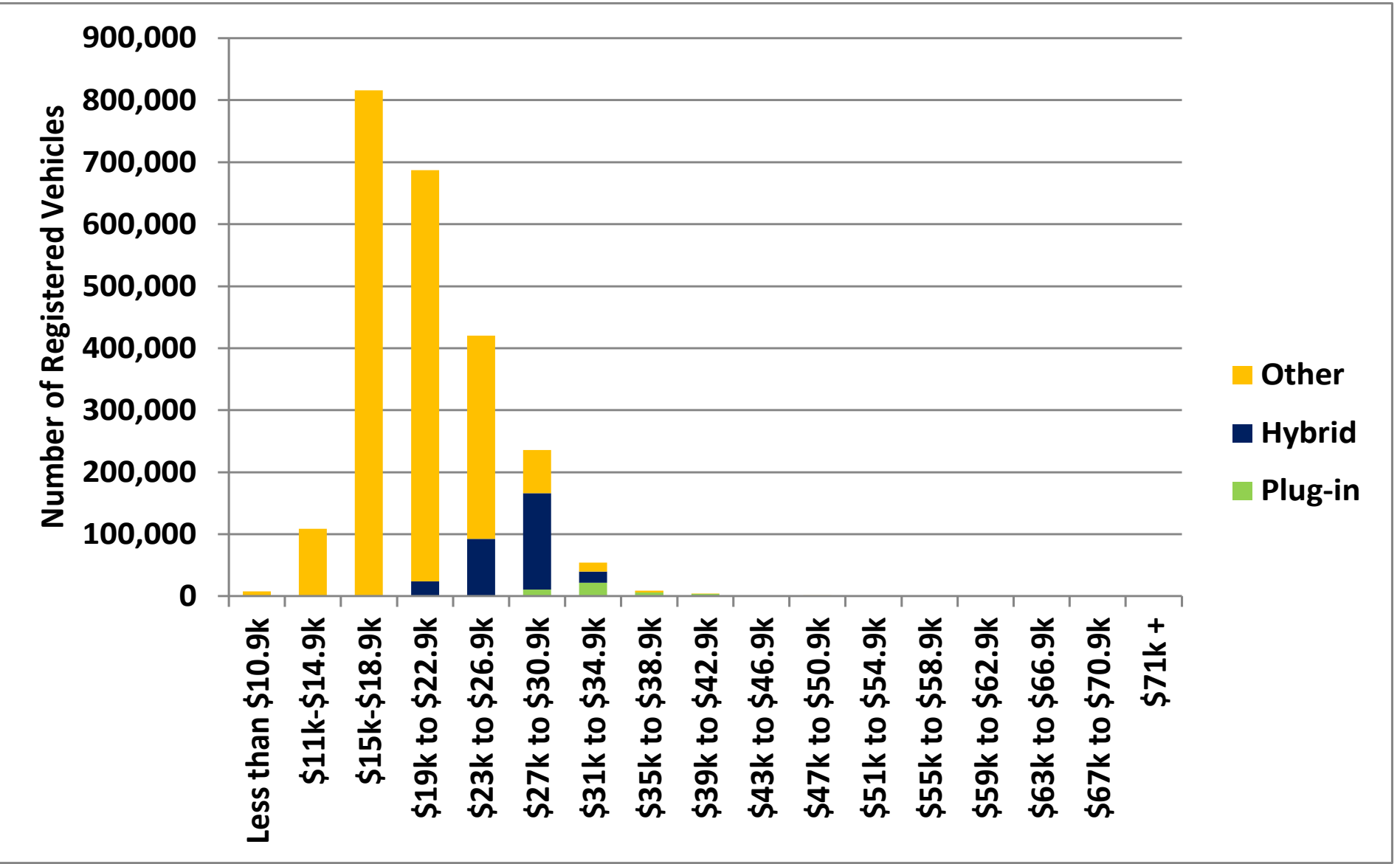
The longer drives in Los Angeles has encouraged PHEVs, which have been very popular for HOV lanes



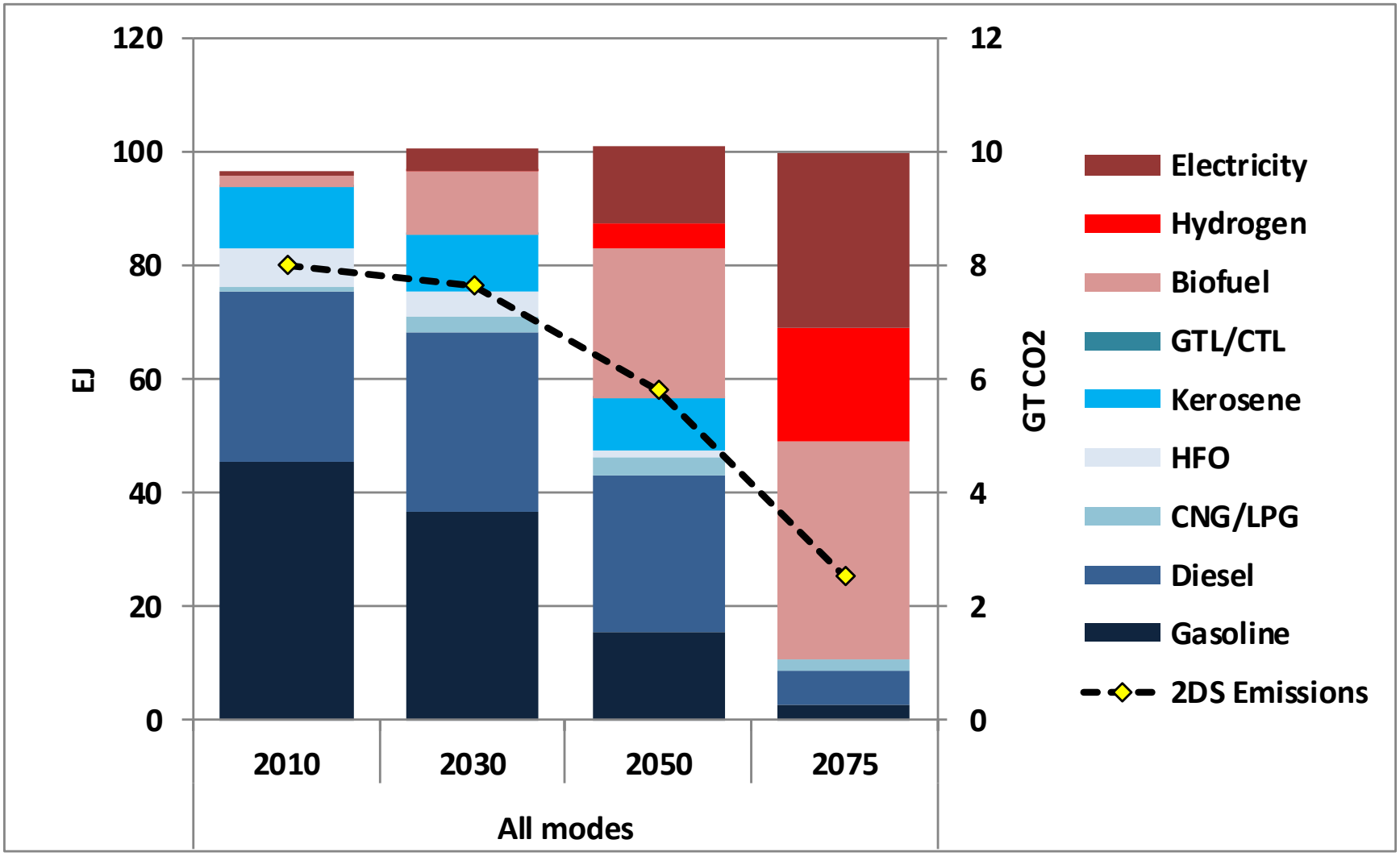
Challenges & opportunities in US PEV market development

- Slow turnover of fleet - 20 years.
- Low cost of gasoline; shift to larger vehicles
- High Cost of ZEV & PEV technologies
- Rate of product rollout into many vehicle classes
- Development rate of consumer awareness, knowledge, experience & product valuation
- Uneven development of charging infrastructure (congestion at chargers)

In US C segment, HEVs and PEVs are at top of price structure (2013)



We'll need it all to hit this 2°C Transport Scenario



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